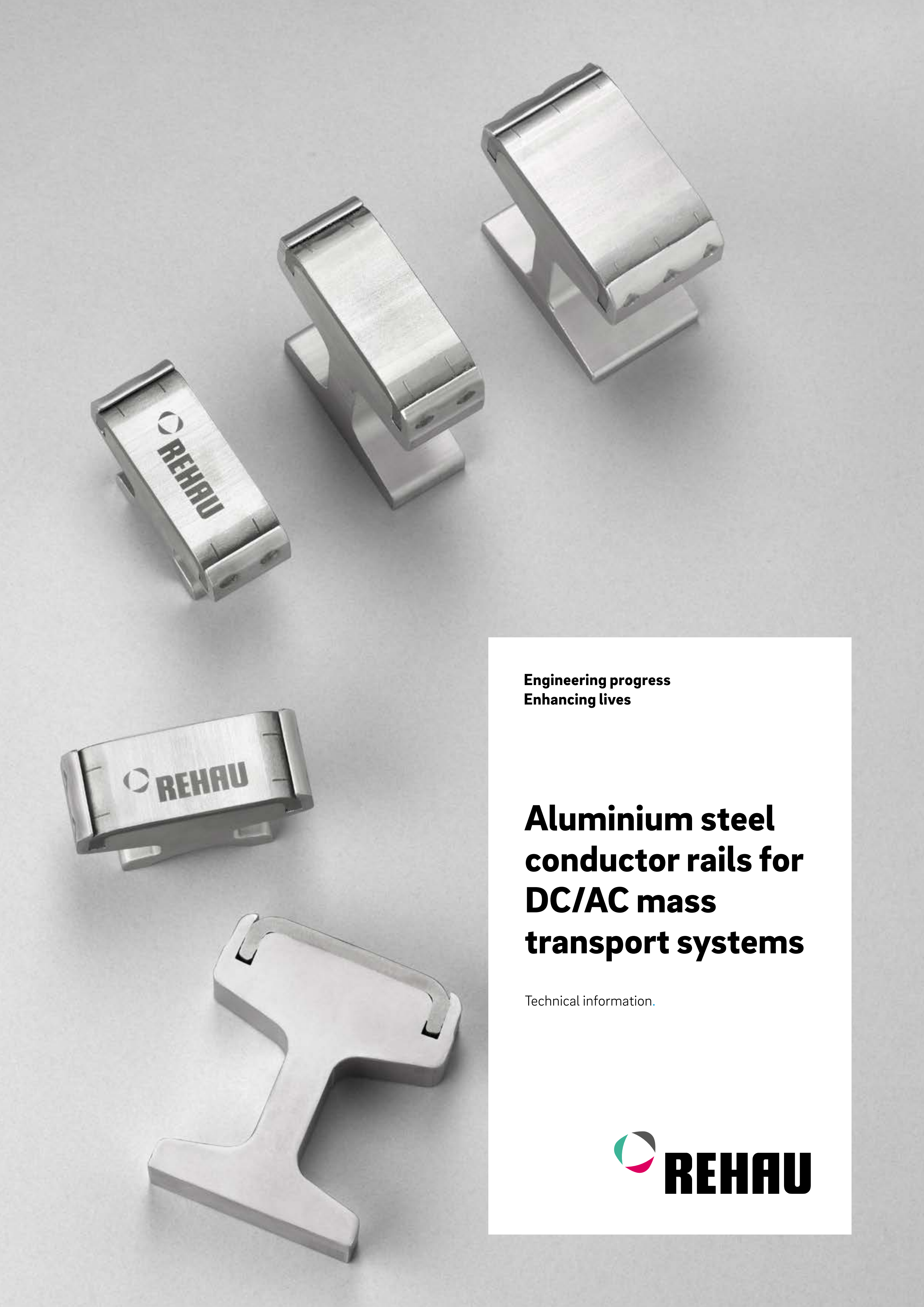

Engineering progress
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Aluminium steel conductor rails for DC/AC mass transport systems

Technical information.

REHAU

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01 Introduction

01.01 General

Aluminium steel conductor rails have been in operation for about 40 years. In the meantime, many changes have been made on the design and most of the mechanical problems with respect to mechanically joining of aluminium body and stainless steel strip have been remedied. However, new requirements with respect to easy installation, electric wear, EMI, and long-term joining of aluminium body and stainless steel strip but easy separation for recycling, usable and safe steel thickness, etc. remain fraught with problems and are not solved by one product yet.

01.02 Installation

Conductor rails are delivered in sections of up to 18 m. They are connected with each other by fishplates. Depending on the relative tolerances of the conductor rail to each other, a difference in position of the stainless steel strip of the joined rail sections may appear. Since the transition from one rail section to the next must be completely level, the stainless steel insert must be ground, which reduces the thickness and, therefore, the lifetime of the conductor rail. In addition, grinding needs to be realized over a longer distance to avoid that the transition becomes a ramp for the collector shoe.
Particularly twisted rail ends of adjacent rails could make a preselection of rails necessary. Joining twisted rail ends often becomes very difficult and is time consuming. Heavy grinding of steel insert on both conductor rails always becomes necessary.

01.03 Electric Wear

Flat surfaces of steel insert without any wavy deviations on steel surface in the longitudinal direction is commonly agreed to be necessary for smooth running and improved electric contact of collector shoes.
The sparking between steel surface and collector shoe as a result of the lack of flatness and straightness of the stainless steel surface has the following adverse effect:

- electro magnetic interference (EMI)
- noise
- electric wear of the steel strip

Considering that often 2/3 of the total wear is due to electric wear (electric sparking) and only 1/3 is due to mechanical abrasion, the smooth running of collector shoe could improve wear resistance considerably. Electric sparking between steel insert and collector shoe is substantially less on flat and non wavy steel surfaces.

01.04 Continuity of mechanical properties

Aluminium profiles are extruded from aluminium billets. In case the production of the conductor rail is continuous, billet after billet is loaded into the extruder. When a new billet is loaded to the extruder, the process stops and a stop mark occurs. Stop marks are like a circular mark appearing around the profile at the exit of the extrusion die and indicate a stop position. Stop marks are consequently in front of the welding zone. In this zone, the material of a new billet follows the material of the old billet. In the welding zone of the two billets the material properties of the extrusion profile become worse, especially material strength is lower and the material properties cannot be guaranteed in that particular rail section.

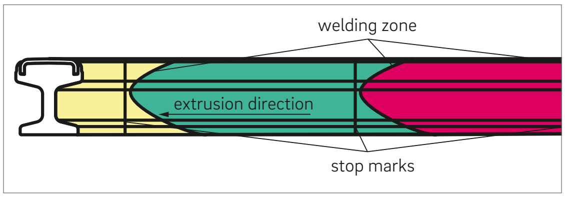


Fig. 01-1 Stop marks in front of the welding zone

01.05 Durable mechanical interlocking

Based on the type of joining the stainless steel strip to the aluminium body, the strength of the mechanical interlocking may be impaired while the thickness of stainless steel strip reduces. This effect may only be experienced after a long operation period. Since the thermal expansion of steel and aluminium is very different, it is of importance that the mechanical interlocking does not depend on the wear of the stainless steel strip.

01.06 Summary

According to our experience and statements made by railway personnel, the following requirements have to be improved:

- overall reduced dimensional tolerances
- non-wavy steel surface
- consistent material properties
- durable mechanical interlocking

02 New aluminium steel conductor rail

02.01 General

Considering the needs as mentioned in chapter „Introduction" on page 4, it was necessary to develop a new type of conductor rail, which incorporates already approved manufacturing processes. The aluminium steel conductor rail is made out of two main parts:
- the extruded aluminium rail (aluminium extrusion profile)
- a pre-manufactured stainless steel insert

In the following, the main parts, the manufacturing process and logical advantages are described in detail.

02.02 Aluminium rail

02.02.01 Material

The aluminium rail is extruded of specially selected aluminium billets within the specified standard aluminium alloy AW6060 or similar. This alloy guarantees state-of-the-art material properties, i.e. high mechanical strength and optimum electric conductivity.

02.02.02 Extrusion die

The aluminium conductor rail is extruded as a single profile. Within each extrusion process there are only minor deviations in absolute dimensions at all, while relative tolerances from conductor rail to conductor rail are going to a minimum.

02.02.03 Stop marks

The aluminium conductor rail is extruded billet on billet, but each section of welding zone (stop mark) is cut out as shown below. None of the aluminium conductor rails shows a stop mark or welding zone of different billets. This guarantees uniform, high mechanical properties across the entire length.

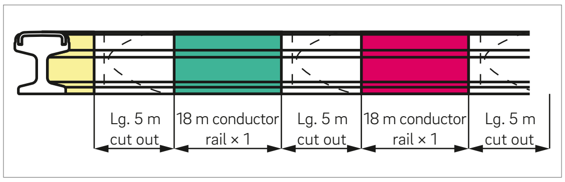


Fig. 02-1 Section of welding zone (stop mark)

02.02.04 Water quenching

The rail is extruded and water quenched in a vertical position to avoid any torsion to the left or right side. Any deformation due to different thermal shock impact (water cooling) is therefore minimized or even avoided.

02.02.05 Inspection certificate

The quality of the material is controlled by chemical analyses of the aluminium billets and mechanical properties of each heat treatment charge are certificated according to inspection certificate (EN 10204-3.1).

02.02.06 Summary

The production method has the following advantages:
- single extruded profile
- same conductor rail height
- water quenching with profile in a vertical position
- no twist of (adjacent) conductor rail ends
- no grinding of steel insert
- no stop marks / no welding zone within conductor rails
- high material strength all across the entire length of the conductor rail
- selected aluminium billets, outstanding material properties
- small symmetry grooves in the fishplate pockets and middle of the aluminium base
- small grooves help to find the drilling position, i.e. drilling holes for joining rails on site

02.03 Stainless steel insert

02.03.01 Stainless steel material

The stainless steel insert is pre-manufactured from the material X6Cr17. This stainless steel quality has been tried and tested for over 40 years under the specific conditions of heavy underground and high-speed railways. Its high chromium content of 17 % guarantees highest stainless steel corrosive resistance. The special stainless steel material offers highest mechanical wear resistance and best electric wear resistance even under difficult conditions of sparking and arcing. The use of high alloy 17 % chrome steel prevents electrical corrosion between aluminium profile and stainless steel insert even in the presence of an electrolyte, wetting by water and frost.

02.03.02 Pre-manufacturing

The stainless steel inserts are manufactured in appropriate lengths and then mechanically adjusted and assembled onto the aluminium rails as one straight long bar. Prior to this, stainless steel strip is bent to take on a C-shape, which gives high rigidity and stability. Any waves or other longitudinal deformations are eliminated. Stainless steel strip is flat on total length and offers smooth steel surface in longitudinal as well as in transversal direction for optimum collector shoe gliding and electric contact under operation.

02.03.03 Steel thickness

The steel thickness determines service life of the conductor rail and is therefore most important in terms of total cost. Therefore, conductor rail ASS 5100 offers 6 mm wear thickness. Due to the method of assembly of the stainless steel insert to the aluminium rail, the whole thickness of 6 mm can be used for wear.

02.04 Assembly of steel insert and aluminium rail

The stainless steel insert and aluminium rail are interlocked mechanically under ambient temperature conditions. After assembly the conductor rail is only shortened / cut to the required length.
The stainless steel insert is fixed to top of the aluminium rail by pressing aluminium continuously on both sides of the aluminium conductor rail into holes within the stainless steel insert. Interlocking is below wear thickness of stainless steel and therefore attachment is not affected by wear, as clamped steel insert may be.
The aluminium interlocking in longitudinal direction of the rail also ensures that the different thermal expansion of steel and aluminium (bi-metal effect) is irrelevant. While the clamping force of clamped steel strip dramatically decreases with the wear thickness, sliding between aluminium and steel may not occur due to the patented aluminium interlocking technique.

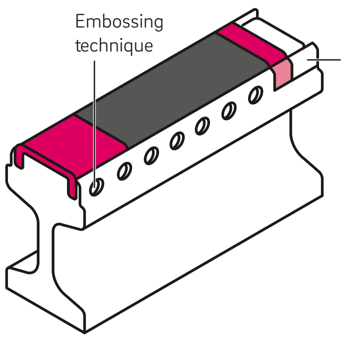


Fig. 02-2 Interlocking avoids the bi-metal effect

The punching is below wear thickness of steel to provide original mechanical interlocking during whole lifetime and also under conditions of heavy wear. No part of steel will come loose even if completely worn. These conditions make the conductor rail more secure under operation and tolerate long intervals between the routine inspections.
No minimum steel thickness must be measured and monitored for safe operation and providing evidence in case of legal investigations. The conductor rail has to be removed after abrasion occurs if the abrasion has reached the aluminium.

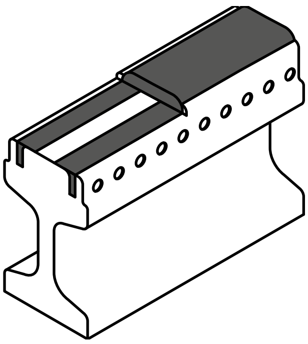


Fig. 02-3 Interlocking below wear surface (steel thickness)

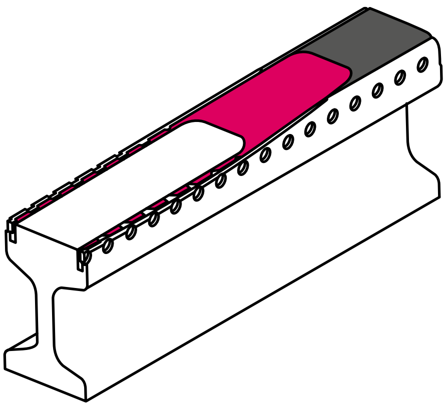


Fig. 02-4 Secure interlocking even with heavy wear

The punching also provides high electric transition contact between aluminium rail and stainless steel insert which is not affected by wear as well. Punching provides high contact pressure and, therefore, high electrical performance. Nevertheless, steel insert is pre-stressed on top of the aluminium rail, this also improves the electrical contact.

Manufacturing technology provides smooth and safe overall surface of the conductor rail. There are no sharp cutting edges or aluminium splices that may injure installation staff.
After expiry of the life of the rail the remnants of the steel strip have to be separated from the aluminium for reasons of recycling and environmental protection. The aluminium interlocking can be removed, and aluminium and steel insert can be 100 % separated, offering customer highest revenue of recycled material.

This method of manufacturing has the following advantages:

- permanent material interlocking at both sides of aluminium conductor rail
- durable interlocking during whole lifetime
- interlocking not affected by wear or remaining steel thickness
- no part of steel will come loose even if it is completely worn
- 100 % aluminium and steel separation possible for reasons of recycling
- no clamping of steel insert
- no longitudinal slippage between aluminium and steel insert possible
- interlocking prevents from damage caused by thermal expansion of steel and aluminium
- high electric contact by interlocking through high press contact

02.04.01 Bending aluminium steel conductor rail

Aluminium steel conductor rail of 12–18 m length is very elastic and pre-bending does not have to be carried out.
For radii R ≥ 100 m the aluminium steel conductor rail is installed elastically into conductor rail supports. If radius R is less than 100 m, prebending at site is recommended.

Made for various systems up to 3000 V

03 Nominal properties of the conductor rail

03.01 Electrical Properties

03.01.01 Electrical Resistance

Electrical resistance R per meter of aluminium steel conductor rail can be calculated according to formula

$$R = \frac{1}{\frac{1}{R_{Alu}} + \frac{1}{R_{Steel}}} \text{ with } R_{Steel} = \frac{1}{\sigma_{Alu}} \times \frac{1\,m}{A_{Steel}} \text{ and } R_{Alu} = \frac{1}{\sigma_{Alu}} \times \frac{1\,m}{A_{Alu}}$$

with A = cross section, σ = specific conductivity.

According to $R_{Steel} = \frac{A_{Alu}}{\sigma_{Steel}} \times \frac{1\,m}{A_{Steel}}$ electrical resistance of stainless steel insert is much higher compared to electrical resistance of the aluminium rail ($R_{Steel} = 150 \times R_{Alu}$) and, thus, does not have to be considered for the calculation of the overall resistance. Furthermore, the steel insert is subject to abrasive wear and steel resistance increases with time and wear.

03.01.02 Electrical Resistance at operation conditions

During operation the conductor rail heats up to a certain operation temperature υ. At high temperature however, the conductor rail resistance is higher according to temperature coefficient α according to $R_{(v)} = R_o\,(1 + \alpha\,(\upsilon - 20\,K))$; $\alpha = 0.004\,K^{-1}$,

$$\text{with } R_0 = \frac{1}{\sigma_{20°C}} \times \frac{1\,m}{A_{Alu}}$$

The electrical resistance of the conductor rail can be calculated according to the above mentioned formula, but aluminium conductivity depends on heat treatment of the aluminium alloy. Conductivity varies in between 30 MS/m (guaranteed minimum) and 32 MS/m for very good conductivity. However, the average value is exceeding 31 MS/m according to long-term experience.
The diagram Fig. 03-1 below shows electrical resistance per meter at different operating temperatures and different aluminium conductivities.

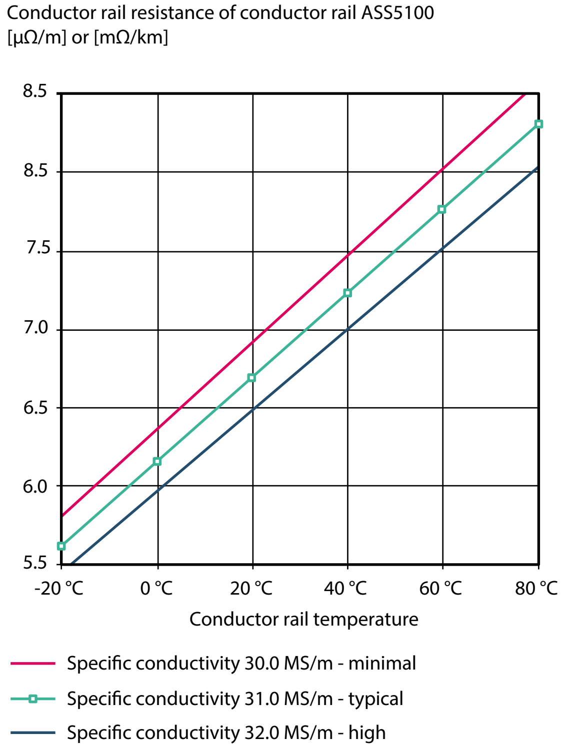


Fig. 03-1 Conductor rail resistance as a function of rail temperature for ASS5100

03.01.03 Electrical current

The electrical current from the power station to the vehicle flows mainly through the aluminium rail. The current which flows through the stainless steel insert can be calculated according to

$$I_{Steel} = \frac{A_{Steel}}{A_{Alu}} \times \frac{\sigma_{Steel}}{\sigma_{Alu}} \times I_{Alu}$$

with A = cross section and σ = specific conductivity with the result of: $\frac{A_{Steel}}{A_{Alu}} = 0.668\ \%$

The electric current through stainless steel insert is less than 0.7 % and therefore negligible as also described before by stainless steel resistance. The electric current is fully transmitted by the aluminium rail.
Along the conductor rail there is no change of current between aluminium rail and stainless steel insert. Any transition resistance from aluminium rail to steel insert is insignificant. Only in the position of collector shoe the current transits the stainless steel insert and flows into the collector shoe.

03.01.04 Transition resistance of aluminium steel conductor rail

A point-to-point measurement as shown in „Fig. 03-2 Point-to-point measurement" was carried out.
As a result, the transition resistance between the aluminium rail and the stainless steel insert is permanently under 30 µΩ. Aluminium embossing provides low electrical contact resistance.

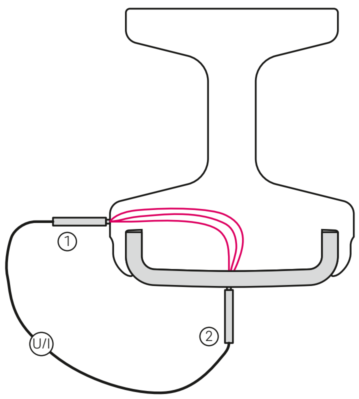


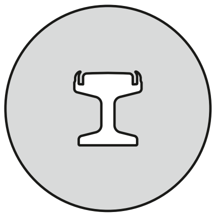
Fig. 03-2 Point-to-point measurement

A typical rail resistance for a track length of 1 km is around to 7 mΩ. Therefore the contact resistance of less than 30 µΩ is negligible. Furthermore the contact resistance between the collector shoe and the power rail is even much higher.

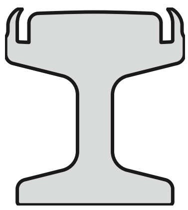
03.01.05 Total transition resistance

Transition resistance between aluminium rail and stainless steel insert is of lower importance than expected. The measurements as given in the above sheet are only a single point-to-point transition resistance. Therefore, these values have less significance to the overall electric quality of conductor rail as explained below:
Each collector shoe contacts the rail on many different contact points or else a part of the surface at the same time. This means that many transition resistances are electrically connected parallel to each others and total transition resistance becomes much less.
If the collector shoe runs on a flat surface, the total transition resistance between conductor rail and collector shoe is much better as operating on wavy steel surfaces because the total contact surface area is larger.
In addition, any contamination on stainless steel surface significantly affects total transition resistance between stainless steel surface and collector shoe, which is much higher than the transition resistance between aluminium and stainless steel.
Considering a total transition resistance between aluminium and stainless steel insert of R_T = 20 µΩ under normal operation conditions, electric loss at I = 1,000 A is P_T (I) = $R_T \times I^2$ = 20 W and can be neglected while considering the total power losses of a 500 m conductor rail.
Example for I = 1,000 A:
P_R (I) = 6.7 µΩ/m × 500 m × I^2 = 3,350 W.
The power loss of a 500 m conductor rail is about 3 kW and much higher compared to any transition resistance power loss.

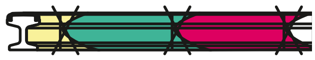
04 Summary



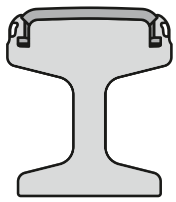
single extrusion profile
- lower tolerance
- no grinding, higher lifetime
- easier installation



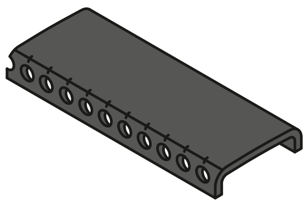
quenching profile in vertical position
- lower torsion
- no grinding, higher lifetime
- easier installation



no welding zone / no stop mark
- constant mechanical properties
- higher short circuit capacity
- higher mechanical stress

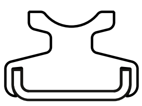
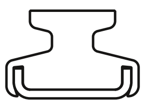
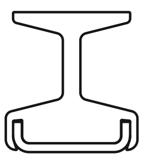
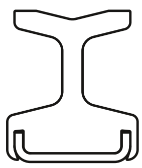
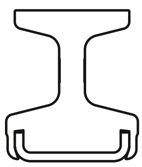
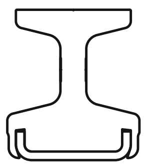
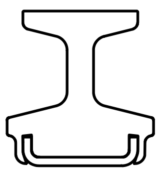


firm steel aluminium interlocking, no clamp
- steel attachment does not depend on clamping force
- interlocking not affected by wear
- no slippage of aluminium and steel possible
- no minimum steel thickness, no need to be supervised



pre-manufactured straight steel inserts
- no bending of steel insert during extrusion
- no wavy steel surface
- less wear, longer product lifetime
- silent operation
- less strain on collector shoe
- less EMI

Aluminium steel power rail system
Different rail sizes (various new rails are already under development)

Type	ASCR 2800	ASCR 3000	ASS 3500	ASCR 4000	ASS 5100	ASS 5100+	ASCR 4900
							
Electr. resistance [15 °C]	11.2 μΩ/m	9.9 μΩ/m	8.5 μΩ/m	7.4 μΩ/m	6.6 μΩ/m	6.4 μΩ/m	5.9 μΩ/m
Mass	12.1 kg/m	12.8 kg/m	14.2 kg/m	16.4 kg/m	17.4 kg/m	17.4 kg/m	18.5 kg/m
Total height	60 mm	60 mm	95 mm	105 mm	105 mm	105 mm	108 mm

05 Technical Data ASS 5100+

05.01 Nominal Dimensions

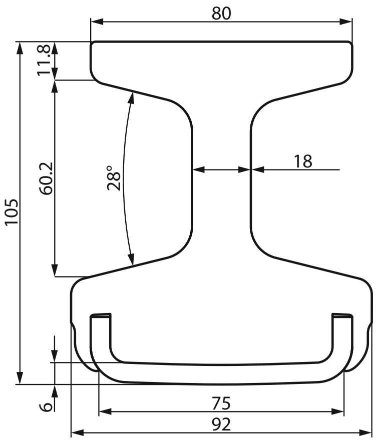


Fig. 05-1 Rail cross section

Fig. 05-2 3D view of the rail

05.02 Nominal data of the conductor rail

The conductor rail ASS 5100+ features the following electrical properties:

total cross section	5,400 mm²
total weight	17.4 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	6.4 µΩ at 15 °C
temperature coefficient	0.004 K^{-1}
transition resistance	10–40 µΩ (point-to-point)
1 s-short circuit	400 kA
nominal current	please see table Tab. 05-1[1]

1 Dependent on local conditions and specification

05.03 Current carrying capacity [A]

Ambient temperature [°C]	Rail temperature [°C] 40	45	50	55	60	65	70	75	80	85	90	95	
0	4271	4509	4730	4939	5137	5326	5506	5678	5845	6005	6160	6311	
5	4011	4268	4505	4728	4938	5137	5327	5508	5682	5849	6011	6167	
10	3729	4008	4265	4504	4728	4939	5139	5329	5512	5687	5855	6018	
15	3418	3726	4006	4264	4503	4728	4940	5141	5333	5517	5693	5863	
20	3069	3415	3724	4005	4263	4504	4730	4943	5145	5338	5523	5700	
25	2669	3068	3414	3723	4005	4265	4506	4733	4947	5151	5345	5531	
30	2189	2668	3066	3413	3724	4006	4267	4509	4737	4953	5157	5352	
35	1554	2188	2667	3066	3414	3725	4009	4270	4514	4743	4959	5165	
40		1554	2187	2667	3067	3415	3727	4012	4274	4519	4749	4967	ΔT=60 K
45			1553	2187	2668	3068	3418	3731	4016	4280	4526	4757	ΔT=55 K
50				1554	2188	2669	3071	3421	3735	4021	4286	4533	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 05-1 Nominal current of conductor rail ASS 5100+, surface emission ratio ≥ 0.3

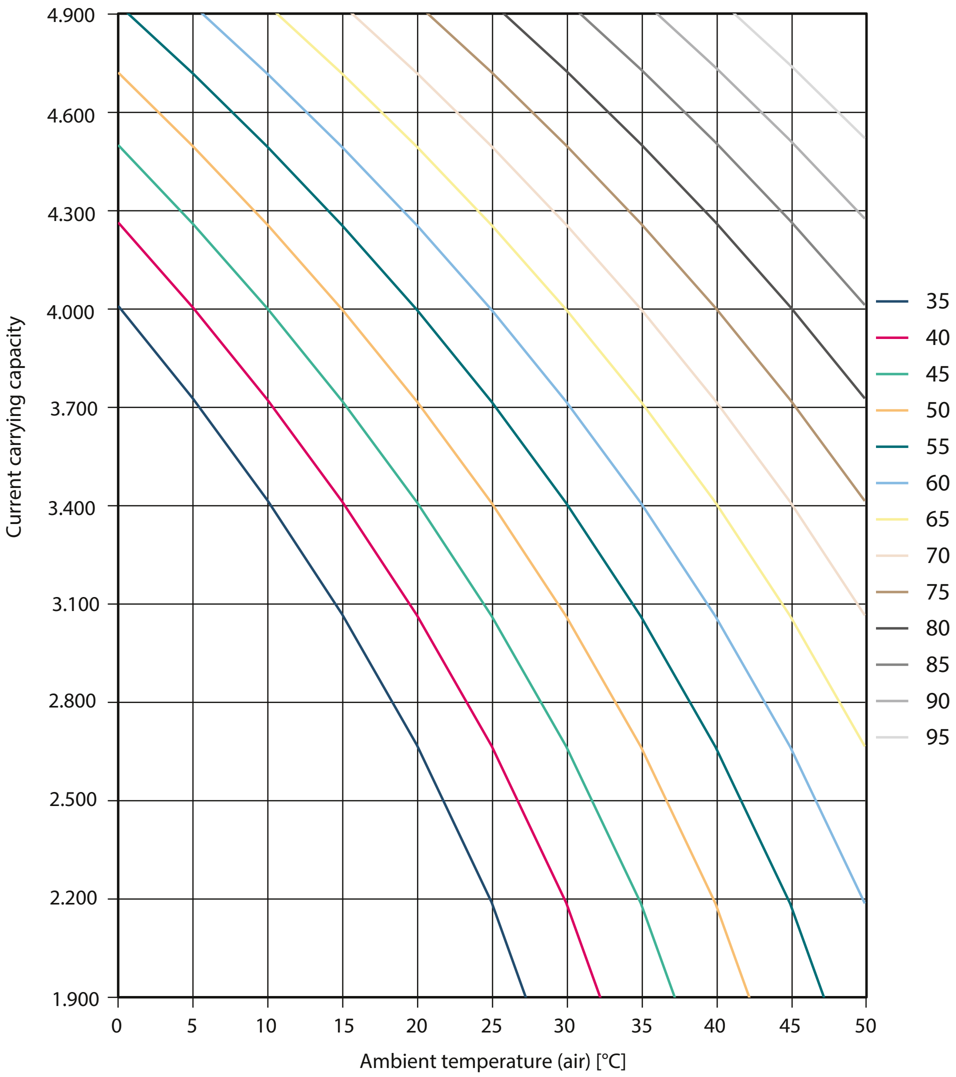


Fig. 05-3 Nominal current of conductor rail ASS 5100+ (dependent on local conditions and specification)

05.04 Nominal technical data of the material

Technical data for		Aluminium	Stainless steel
specific electric conductivity, min (20 °C)	MS/m	32	–
specific electric conductivity, typical (20 °C)	MS/m	32–33	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

05.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASS 5100+

Rail temperature increase from 80 °C to 200 °C

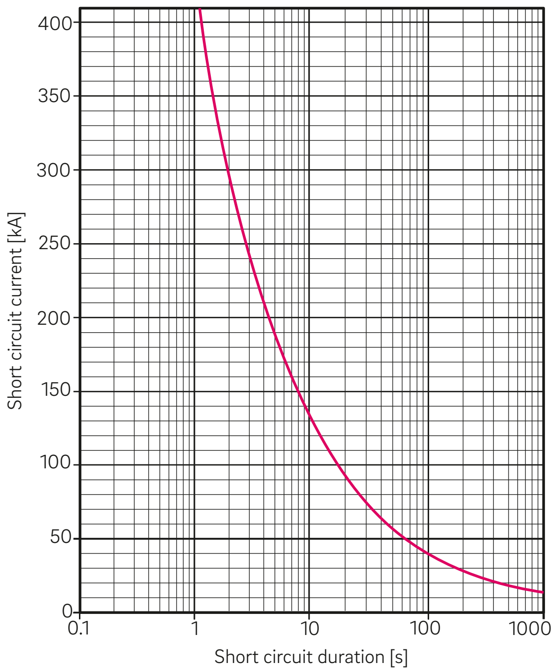


Fig. 05-4 Diagram of short circuit withstand of conductor rail ASS 5100+

05.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „05.03 Current carrying capacity [A]" show the values. For an ambient temperature of 30 °C and a permitted operating temperature of 75 °C, the nominal current is 4,509 A.

05.07 Mechanical properties

05.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

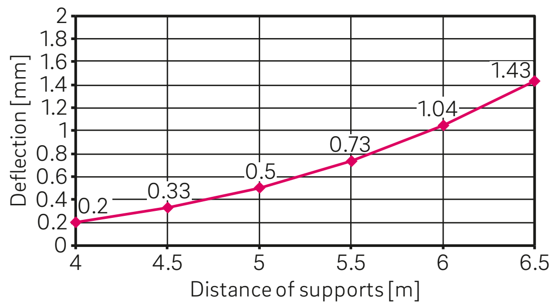


Fig. 05-5 Calculated deflection (ASS 5100+)

05.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.

$\alpha_{Steel} = 10.0\times10^{-6}\ K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\ K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail}$ = $20.4\times10^{-6}\ K^{-1}$.

06 Technical Data ASS 5100

06.01 Nominal Dimensions

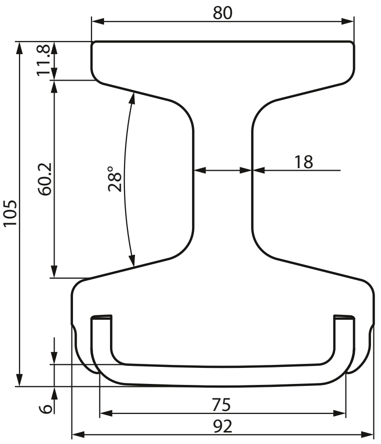


Fig. 06-1 Rail cross section

Fig. 06-2 3D view of the Rail

06.02 Nominal data of the conductor rail

The conductor rail ASS 5100 features the following electrical properties:

total cross section	5,400 mm²
total weight	17.4 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	6.6 µΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	390 kA
nominal current	please see table Tab. 06-1[2]

2 Dependent on local conditions and specification

06.03 Current carrying capacity [A]

Ambient temperature [°C]	Rail temperature [°C] 40	45	50	55	60	65	70	75	80	85	90	95	
0	3966	4184	4387	4578	4759	4931	5094	5251	5401	5546	5686	5821	
5	3723	3958	4177	4380	4572	4754	4926	5090	5248	5399	5545	5686	
10	3459	3716	3951	4170	4375	4567	4749	4923	5088	5246	5399	5545	
15	3168	3452	3709	3946	4165	4370	4564	4747	4921	5087	5246	5399	
20	2844	3163	3447	3704	3941	4161	4367	4561	4745	4920	5087	5247	
25	2472	2839	3158	3442	3700	3938	4158	4365	4560	4744	4920	5088	
30	2026	2468	2835	3154	3438	3697	3935	4156	4364	4560	4745	4922	
35	1438	2022	2464	2831	3151	3436	3695	3934	4156	4364	4560	4747	
40		1435	2020	2461	2829	3148	3434	3694	3933	4156	4365	4562	ΔT=65 K
45			1434	2018	2459	2827	3147	3433	3694	3934	4157	4367	ΔT=55 K
50				1432	2016	2458	2826	3146	3433	3694	3935	4160	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 06-1 Nominal current of conductor rail ASS 5100, surface emission ratio ≥ 0.3

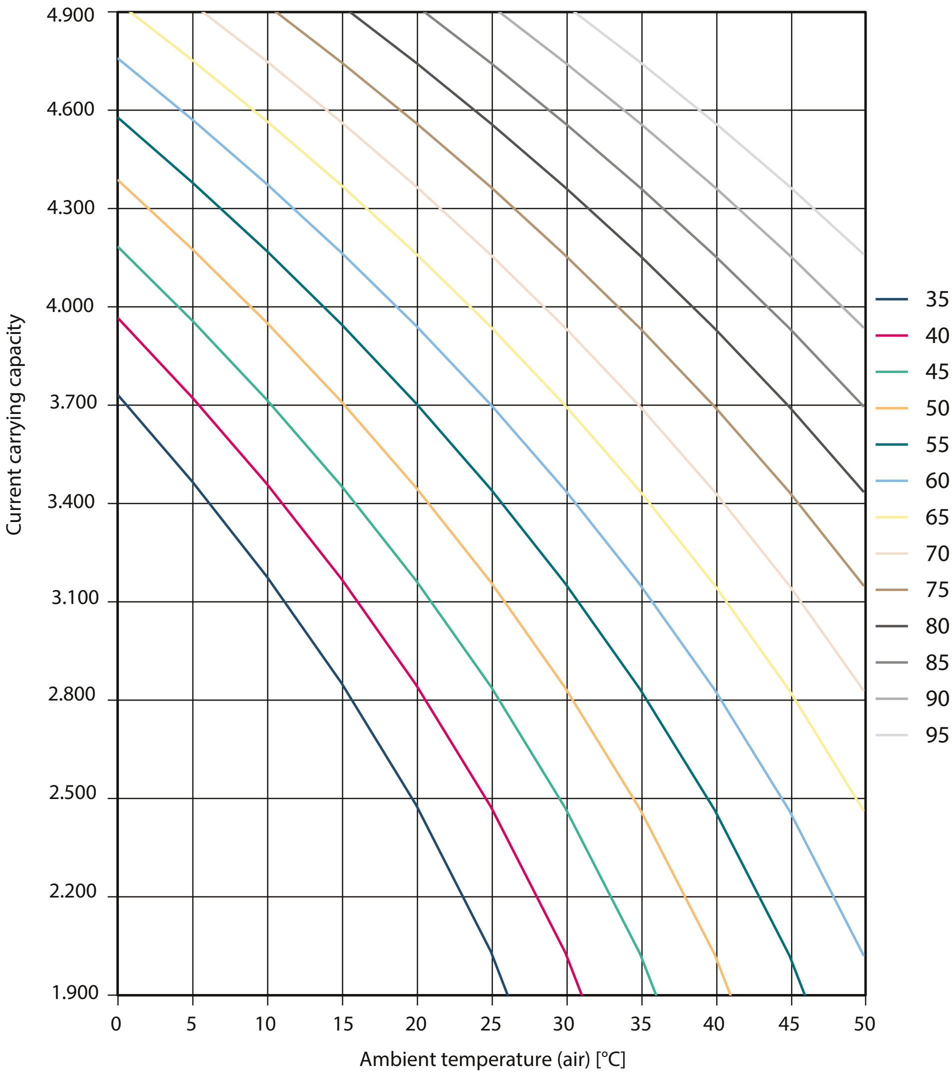


Fig. 06-3 Nominalcurrent of conductor rail ASS 5100 (dependent on local conditions and specification)

06.04 Nominal technical data of the material

Technical data for		Aluminium	Stainless steel
specific electric conductivity, min (20 °C)	MS/m	31	–
specific electric conductivity, typical (20 °C)	MS/m	31–32	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

06.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASS 5100
Rail temperature increase from 80 °C to 200 °C

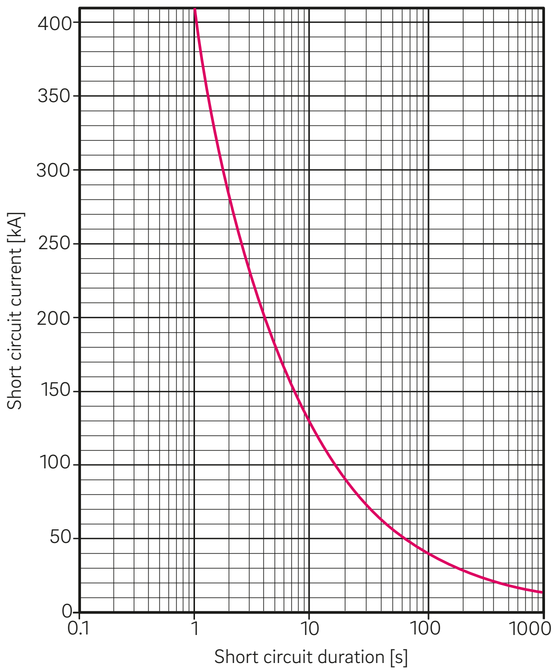


Fig. 06-4 Diagram of short circuit withstand of conductor rail ASS 5100

06.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „06.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 4,745 A.

06.07 Mechanical properties

06.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

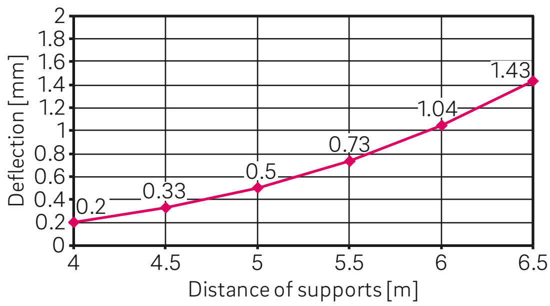


Fig. 06-5 Calculated deflection (ASS 5100)

06.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.
$\alpha_{Steel} = 10.0\times10^{-6}\ K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\ K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail} = 20.4\times10^{-6}\ K^{-1}$.

07 Technical Data ASCR 4900

07.01 Nominal Dimensions

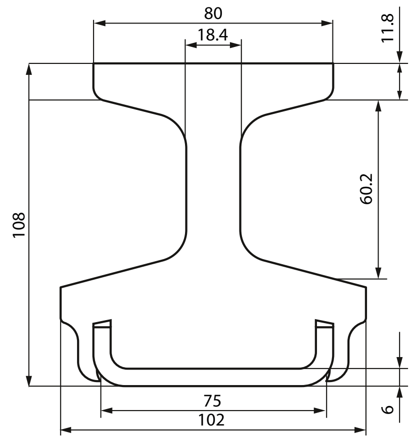


Fig. 07-1 Rail cross section

Fig. 07-2 3D view of the Rail

07.02 Nominal data of the conductor rail

The conductor rail ASCR 4900 features the following electrical properties:

total cross section	5,825 mm²
total weight	18.5 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	5.9 μΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	420 kA
nominal current	please see table Tab. 07-1[1]

1 Dependent on local conditions and specification

07.03 Current carrying capacity [A]

Ambient temperature [°C] \ **Rail temperature** [°C]	40	45	50	55	60	65	70	75	80	85	90	95	
0	4128	4353	4563	4761	4948	5125	5293	5455	5609	5758	5902	6041	
5	3873	4117	4343	4554	4752	4940	5117	5287	5449	5605	5755	5899	
10	3598	3864	4108	4335	4546	4745	4933	5112	5282	5445	5602	5752	
15	3295	3589	3856	4100	4327	4539	4739	4928	5107	5278	5442	5600	
20	2957	3287	3582	3848	4094	4321	4534	4734	4924	5104	5276	5441	
25	2569	2950	3281	3575	3842	4088	4316	4529	4730	4921	5102	5275	
30	2105	2564	2945	3275	3570	3837	4083	4312	4526	4728	4919	5101	
35	1494	2101	2559	2940	3270	3565	3833	4080	4309	4524	4727	4919	
40		1491	2097	2555	2936	3266	3562	3830	4078	4308	4523	4726	ΔT=65 K
45			1488	2094	2552	2932	3263	3559	3828	4076	4307	4523	ΔT=55 K
50				1486	2091	2549	2930	3261	3558	3827	4076	4307	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 07-1 Nominal current of conductor rail ASCR 4900, surface emission ratio ≥ 0.3

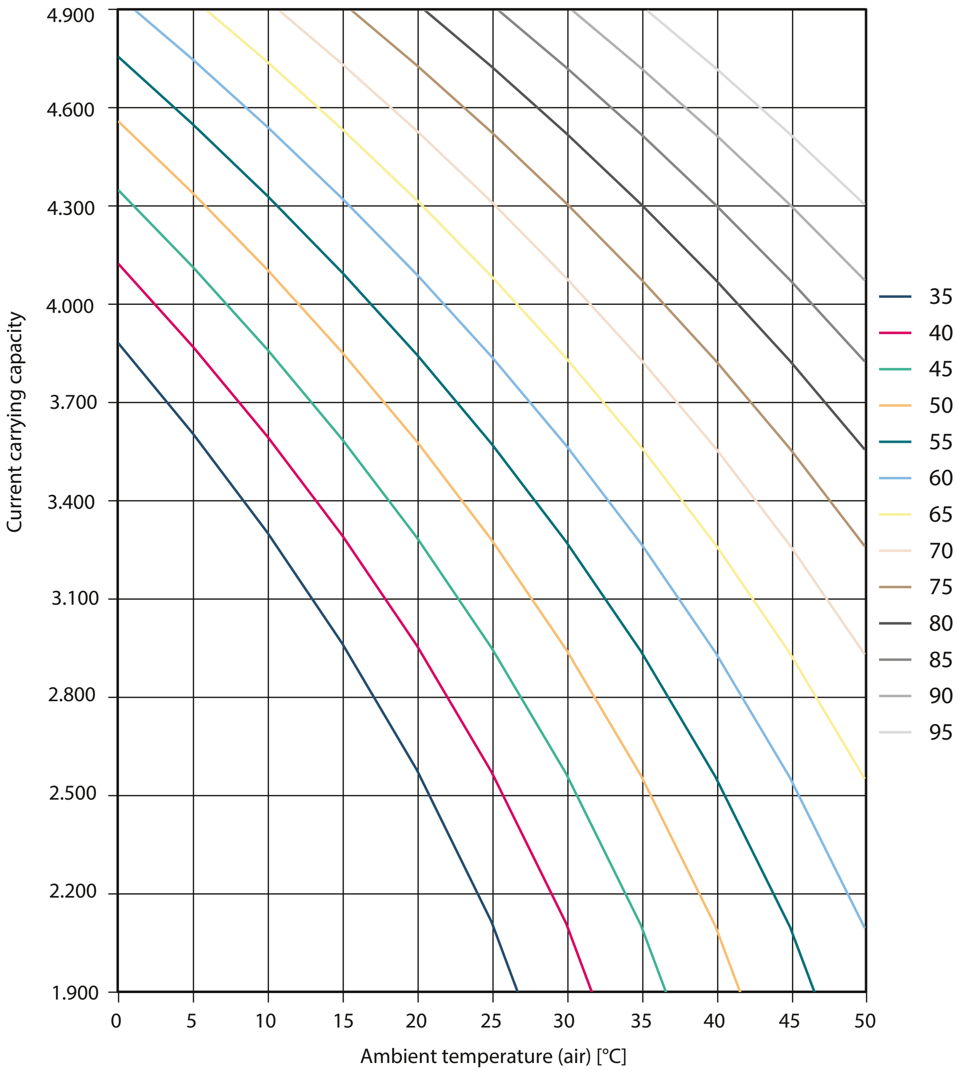


Fig. 07-3 Nominalcurrent of conductor rail ASCR 4900 (dependent on local conditions and specification)

07.04 Nominal technical data of the material

Technical data for		**Aluminium**	**Stainless steel**
specific electric conductivity, min (20 °C)	MS/m	32	–
specific electric conductivity, typical (20 °C)	MS/m	32–33	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

07.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASCR 4900

Rail temperature increase from 80 °C to 200 °C

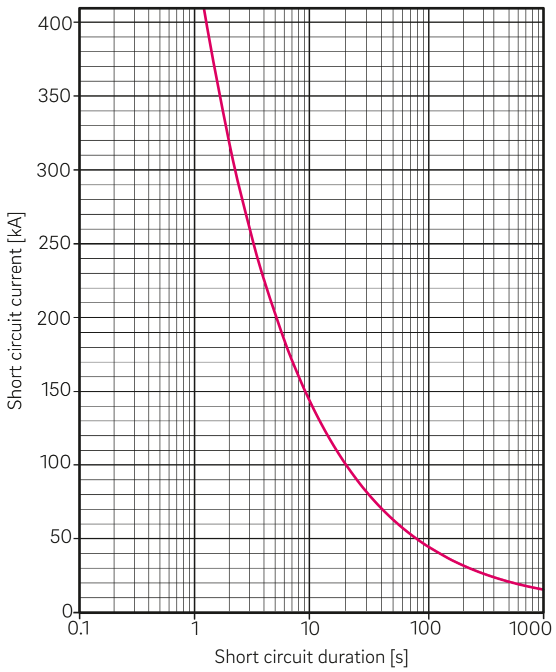


Fig. 07-4 Diagram of short circuit withstand of conductor rail ASCR 4900

07.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „07.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 4,924 A.

07.07 Mechanical properties

07.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

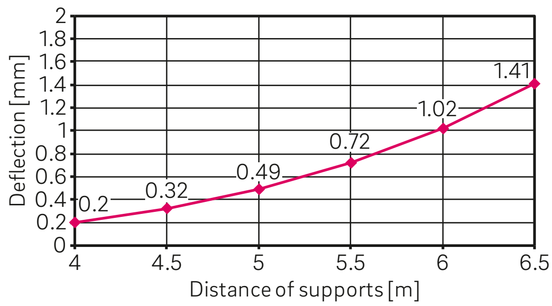


Fig. 07-5 Calculated deflection (ASCR 4900)

07.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.

$\alpha_{Steel} = 10.0\times10^{-6}\,K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\,K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\,Rail} = 20.5\times10^{-6}\,K^{-1}$.

08 Technical Data ASCR 4000

08.01 Nominal Dimensions

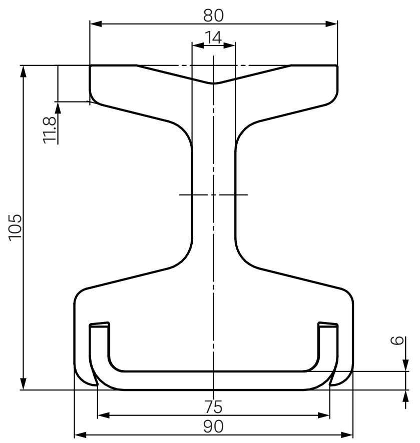


Fig. 08-1 Rail cross section

Fig. 08-2 3D view of the Rail

08.02 Nominal data of the conductor rail

The conductor rail ASCR 4000 features the following electrical properties:

total cross section	5,035 mm²
total weight	16.4 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	7.4 µΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	360 kA
nominal current	please see table Tab. 08-1[2]

2 Dependent on local conditions and specification

08.03 Current carrying capacity [A]

Ambient temperature [°C] \ Rail temperature [°C]	40	45	50	55	60	65	70	75	80	85	90	95	
0	3777	3985	4179	4361	4533	4697	4853	5003	5147	5285	5419	5548	
5	3546	3770	3978	4173	4356	4529	4694	4851	5001	5146	5285	5420	
10	3294	3539	3764	3973	4168	4352	4526	4691	4849	5000	5146	5286	
15	3018	3288	3534	3759	3969	4164	4349	4524	4690	4849	5001	5147	
20	2709	3013	3284	3529	3755	3965	4162	4347	4523	4690	4850	5003	
25	2355	2705	3009	3280	3526	3753	3963	4160	4347	4523	4691	4851	
30	1930	2351	2701	3005	3277	3524	3751	3962	4160	4347	4524	4693	
35	1370	1927	2348	2698	3003	3275	3522	3750	3962	4161	4348	4527	
40		1368	1925	2346	2696	3001	3274	3522	3750	3963	4162	4351	ΔT=65 K
45			1366	1923	2344	2695	3000	3273	3522	3751	3965	4165	ΔT=55 K
50				1365	1922	2343	2694	3000	3274	3523	3753	3967	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 08-1 Nominal current of conductor rail ASCR 4000, surface emission ratio ≥ 0.3

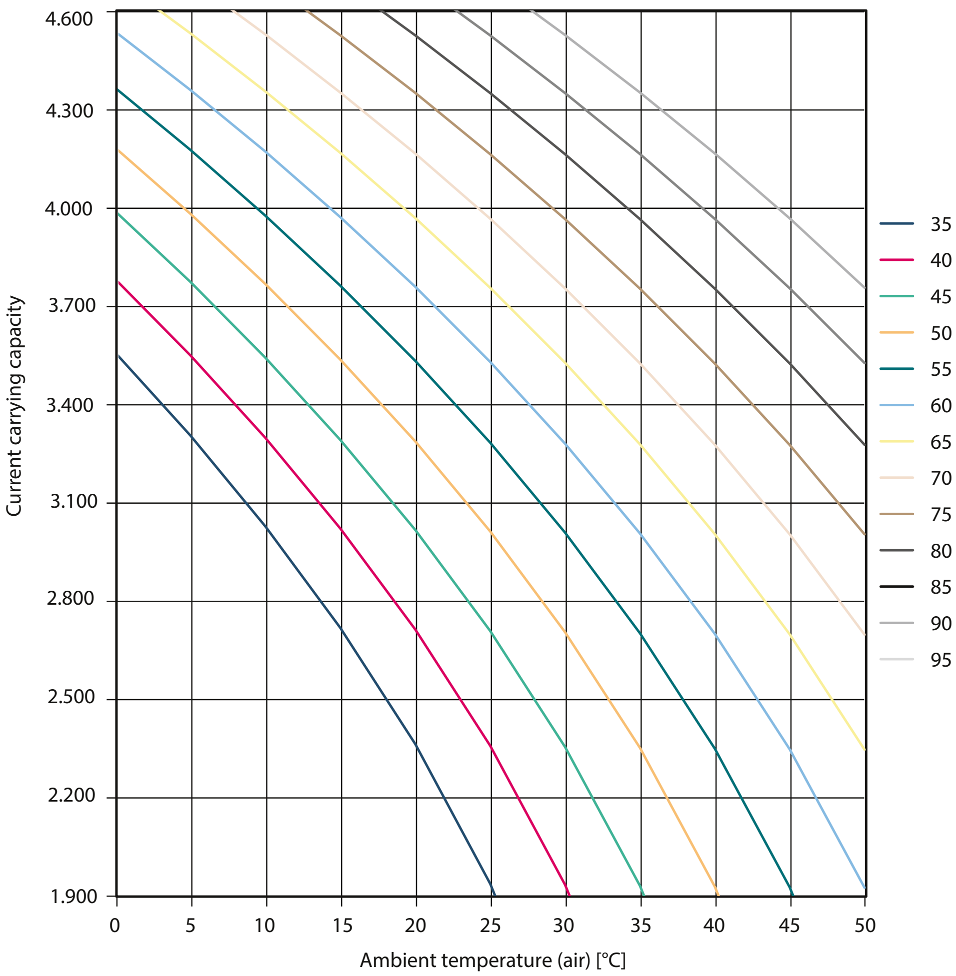


Fig. 08-3 Nominalcurrent of conductor rail ASCR 4000 (dependent on local conditions and specification)

08.04 Nominal technical data of the material

Technical data for		**Aluminium**	**Stainless steel**
specific electric conductivity, min (20 °C)	MS/m	30	–
specific electric conductivity, typical (20 °C)	MS/m	30–32	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

08.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASCR 4000

Rail temperature increase from 80 °C to 200 °C

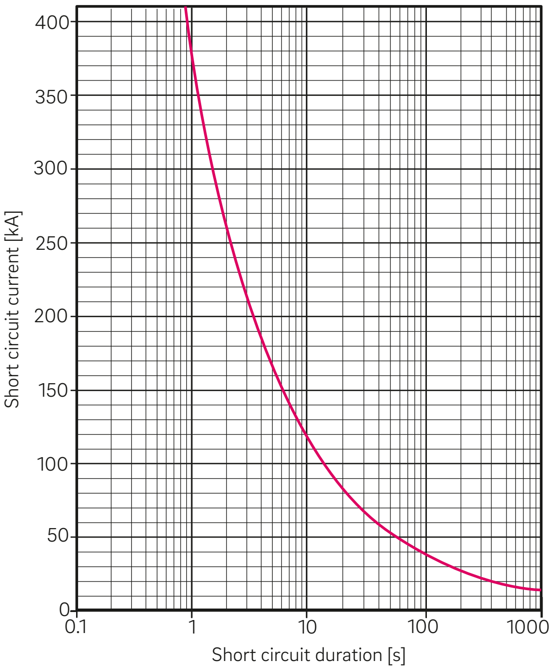


Fig. 08-4 Diagram of short circuit withstand of conductor rail ASCR 4000

08.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „08.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 4,523 A.

08.07 Mechanical properties

08.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

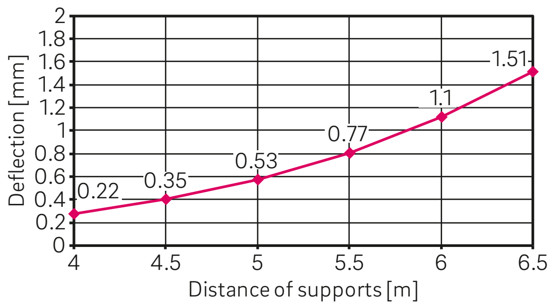


Fig. 08-5 Calculated deflection (ASCR 4000)

08.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.

α_{Steel} = 10.0×10^{-6} K^{-1}, α_{Alu} = 23.1×10^{-6} K^{-1}. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail}$ = 20.2×10^{-6} K^{-1}.

09 Technical Data ASS 3500

09.01 Nominal Dimensions

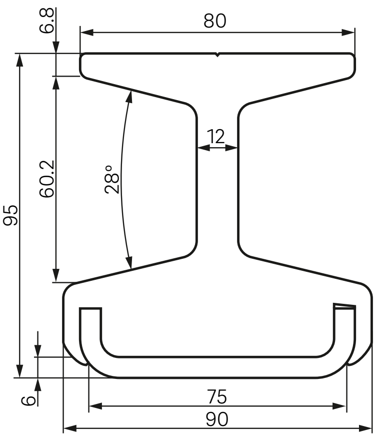


Fig. 09-1 Rail cross section

Fig. 09-2 3D view of the Rail

09.02 Nominal data of the conductor rail

The conductor rail ASS 3500 features the following electrical properties:

total cross section	4,220 mm²
total weight	14.2 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	9.1 µΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	300 kA
nominal current	please see table Tab. 09-1[3]

3 Dependent on local conditions and specification

09.03 Current carrying capacity [A]

Ambient temperature [°C]	Rail temperature [°C] 40	45	50	55	60	65	70	75	80	85	90	95	
0	3353	3538	3711	3874	4028	4174	4314	4448	4576	4700	4820	4936	
5	3148	3348	3534	3707	3871	4025	4172	4313	4448	4577	4702	4823	
10	2926	3144	3344	3530	3704	3869	4024	4172	4313	4449	4579	4705	
15	2681	2921	3140	3341	3528	3703	3867	4024	4172	4315	4451	4582	
20	2407	2677	2918	3137	3339	3526	3702	3867	4024	4174	4317	4454	
25	2093	2404	2674	2916	3136	3338	3526	3702	3868	4026	4176	4320	
30	1715	2090	2402	2672	2914	3135	3337	3526	3703	3870	4029	4180	
35	1218	1713	2088	2400	2671	2914	3134	3338	3527	3705	3873	4032	
40		1216	1712	2087	2399	2671	2914	3135	3339	3529	3708	3877	ΔT=65 K
45			1216	1711	2086	2399	2671	2915	3137	3341	3532	3712	ΔT=55 K
50				1215	1711	2086	2399	2672	2916	3139	3344	3536	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 09-1 Nominal current of conductor rail ASS 3500, surface emission ratio ≥ 0.3

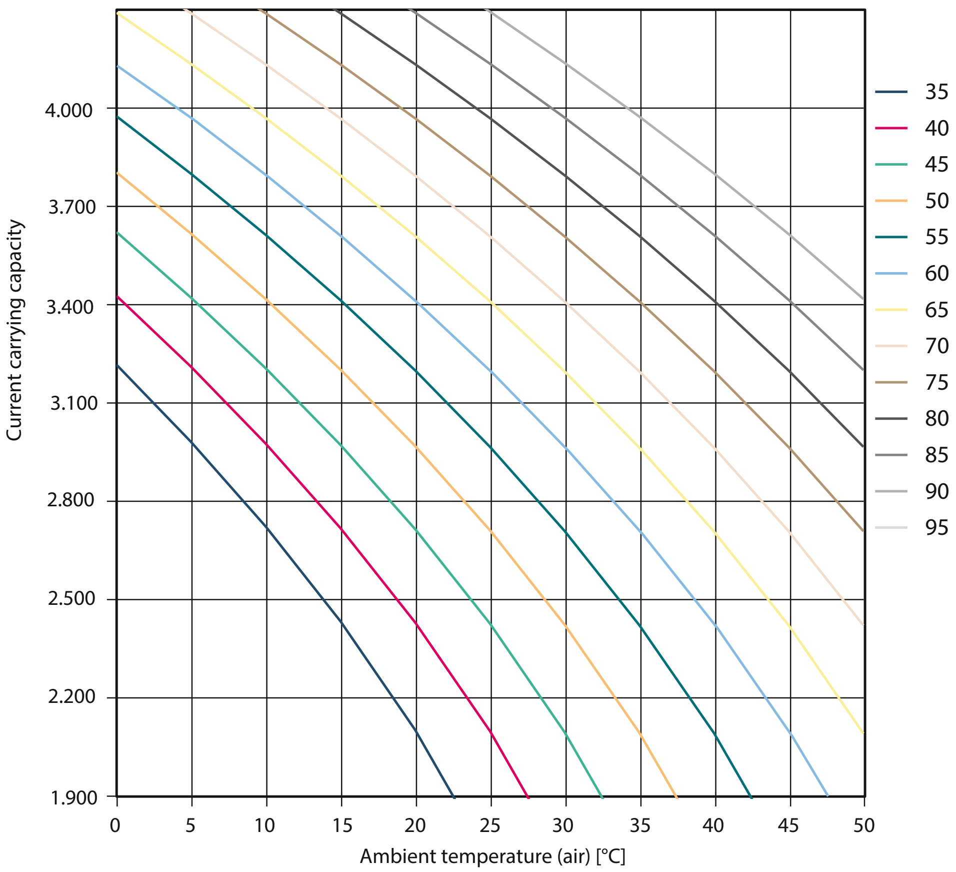


Fig. 09-3 Nominalcurrent of conductor rail ASS 3500 (dependent on local conditions and specification)

09.04 Nominal technical data of the material

Technical data for		Aluminium	Stainless steel
specific electric conductivity, min (20 °C)	MS/m	30	–
specific electric conductivity, typical (20 °C)	MS/m	30–32	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

09.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASCR 3500

Rail temperature increase from 80 °C to 200 °C

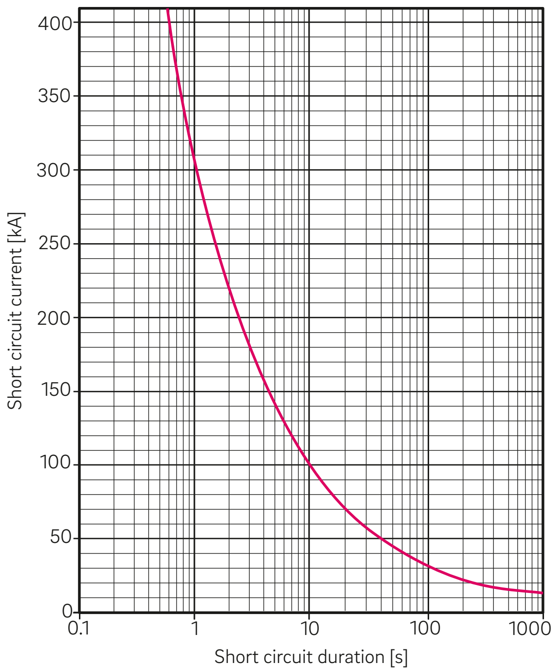


Fig. 09-4 Diagram of short circuit withstand of conductor rail ASS 3500

09.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „09.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 4,024 A.

09.07 Mechanical properties

09.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

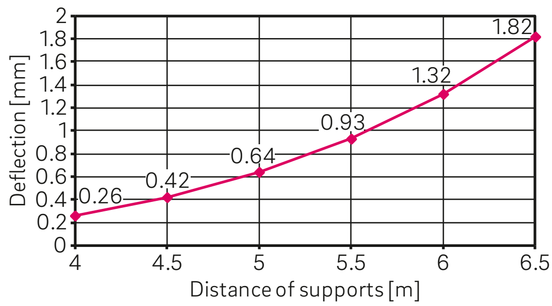


Fig. 09-5 Calculated deflection (ASS 3500)

09.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.

$\alpha_{Steel} = 10.0\times10^{-6}\ K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\ K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail} = 19.6\times10^{-6}\ K^{-1}$.

10 Technical Data ASCR 3000

10.01 Nominal Dimensions

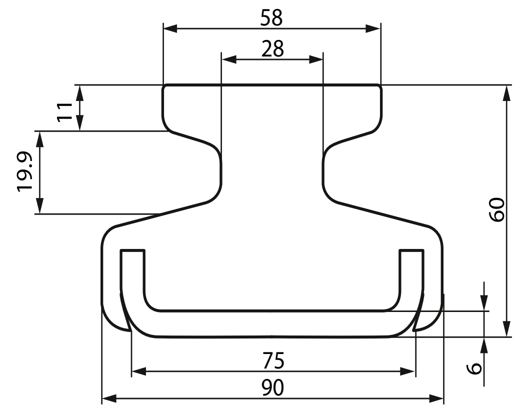


Fig. 10-1 Rail cross section

Fig. 10-2 3D view of the Rail

10.02 Nominal data of the conductor rail

The conductor rail ASCR 3000 features the following electrical properties:

total cross section	3,719 mm²
total weight	12.8 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	9.9 μΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	275 kA
nominal current	please see table Tab. 10-1[4]

4 Dependent on local conditions and specification

10.03 Current carrying capacity [A]

Ambient temperature [°C]	Rail temperature [°C] 40	45	50	55	60	65	70	75	80	85	90	95	
0	3085	3255	3415	3565	3707	3842	3972	4095	4215	4329	4440	4548	
5	2896	3081	3252	3412	3563	3706	3842	3972	4097	4216	4332	4444	
10	2692	2893	3078	3250	3410	3562	3706	3842	3973	4099	4219	4336	
15	2467	2689	2890	3076	3248	3410	3562	3706	3844	3975	4102	4223	
20	2215	2464	2687	2889	3075	3248	3410	3563	3708	3846	3979	4106	
25	1926	2213	2463	2685	2888	3074	3248	3411	3565	3711	3850	3983	
30	1579	1924	2212	2461	2685	2888	3075	3249	3413	3567	3714	3854	
35	1121	1578	1923	2211	2461	2685	2888	3076	3251	3416	3571	3718	
40		1120	1577	1923	2210	2461	2686	2890	3078	3254	3419	3575	ΔT=65 K
45			1120	1576	1922	2211	2462	2687	2892	3081	3258	3424	ΔT=55 K
50				1120	1576	1923	2212	2464	2689	2895	3085	3262	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 10-1 Nominal current of conductor rail ASCR 3000, surface emission ratio ≥ 0.3

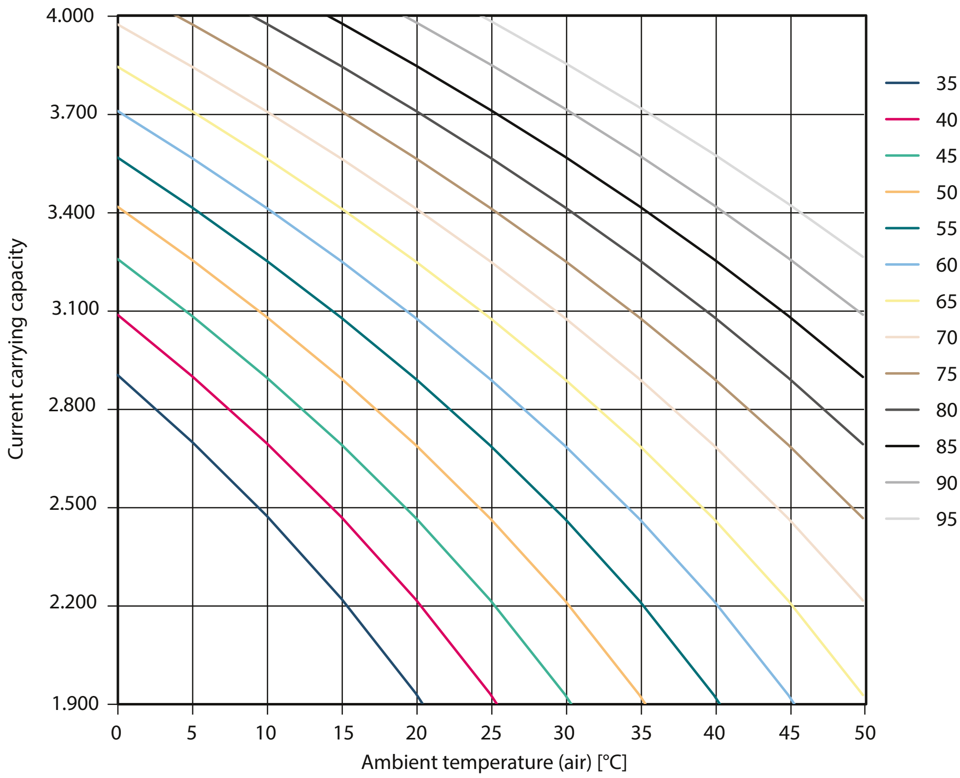


Fig. 10-3 Nominalcurrent of conductor rail ASCR 3000 (dependent on local conditions and specification)

10.04 Nominal technical data of the material

Technical data for		Aluminium	Stainless steel
specific electric conductivity, min (20 °C)	MS/m	32	–
specific electric conductivity, typical (20 °C)	MS/m	32–33	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

10.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASCR 3000
Rail temperature increase from 80 °C to 200 °C

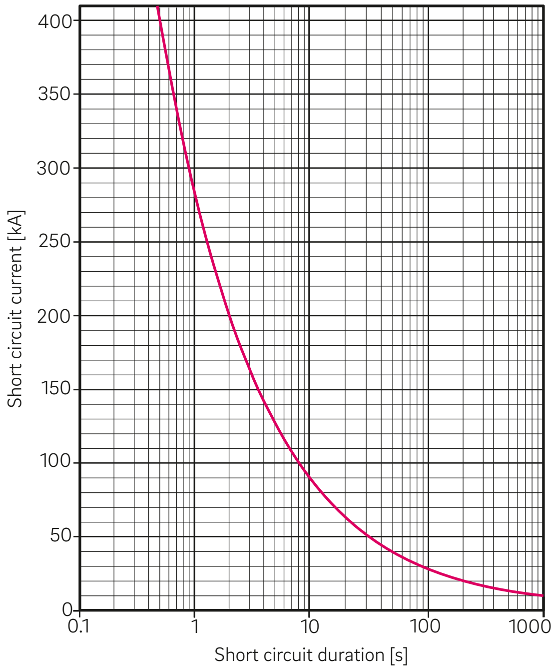


Fig. 10-4 Diagram of short circuit withstand of conductor rail ASCR 3000

10.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „10.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 3,708 A.

10.07 Mechanical properties

10.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

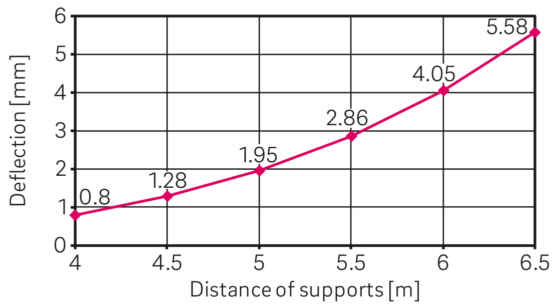


Fig. 10-5 Calculated deflection (ASCR 3000)

10.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.
$\alpha_{Steel} = 10.0\times10^{-6}\ K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\ K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail} = 19.1\times10^{-6}\ K^{-1}$.

11 Technical Data ASCR 2800

11.01 Nominal Dimensions

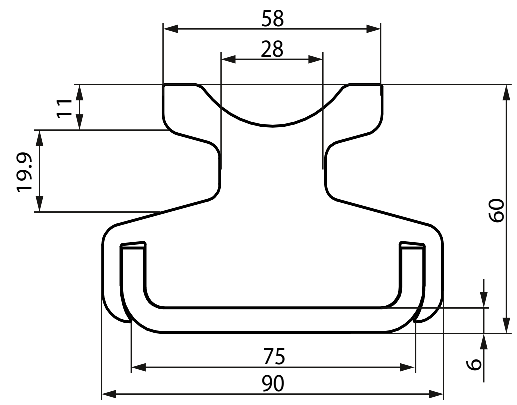


Fig. 11-1 Rail cross section

Fig. 11-2 3D view of the Rail

11.02 Nominal data of the conductor rail

The conductor rail ASCR 2800 features the following electrical properties:

total cross section	3,443 mm²
total weight	12.1 kg/m
effective useable thickness of steel insert	6 mm
electrical resistance per m	11.2 µΩ at 15 °C
temperature coefficient	0.004 K^{-1}
1 s-short circuit	270 kA
nominal current	please see table Tab. 11-1[5]

5 Dependent on local conditions and specification

11.03 Current carrying capacity [A]

Ambient temperature [°C] \ Rail temperature [°C]	40	45	50	55	60	65	70	75	80	85	90	95	
0	2875	3034	3183	3324	3456	3583	3703	3819	3930	4038	4142	4242	
5	2700	2872	3032	3181	3322	3456	3583	3704	3821	3933	4041	4146	
10	2509	2697	2870	3030	3180	3322	3456	3584	3706	3823	3936	4045	
15	2300	2507	2695	2868	3029	3180	3322	3457	3585	3708	3827	3940	
20	2065	2298	2505	2694	2867	3029	3180	3323	3459	3588	3712	3831	
25	1796	2064	2296	2504	2693	2868	3030	3182	3326	3462	3592	3716	
30	1472	1794	2062	2296	2504	2694	2868	3031	3184	3328	3466	3596	
35	1046	1471	1794	2062	2295	2504	2695	2870	3034	3187	3332	3470	
40		1045	1471	1793	2062	2296	2505	2696	2872	3037	3191	3337	ΔT=65 K
45			1044	1471	1793	2063	2297	2507	2699	2875	3040	3195	ΔT=55 K
50				1044	1471	1794	2064	2299	2509	2702	2879	3045	ΔT=50 K
										ΔT=30 K	ΔT=35 K	ΔT=40 K	ΔT=45 K

Tab. 11-1 Nominal current of conductor rail ASCR 2800, surface emission ratio ≥ 0.3

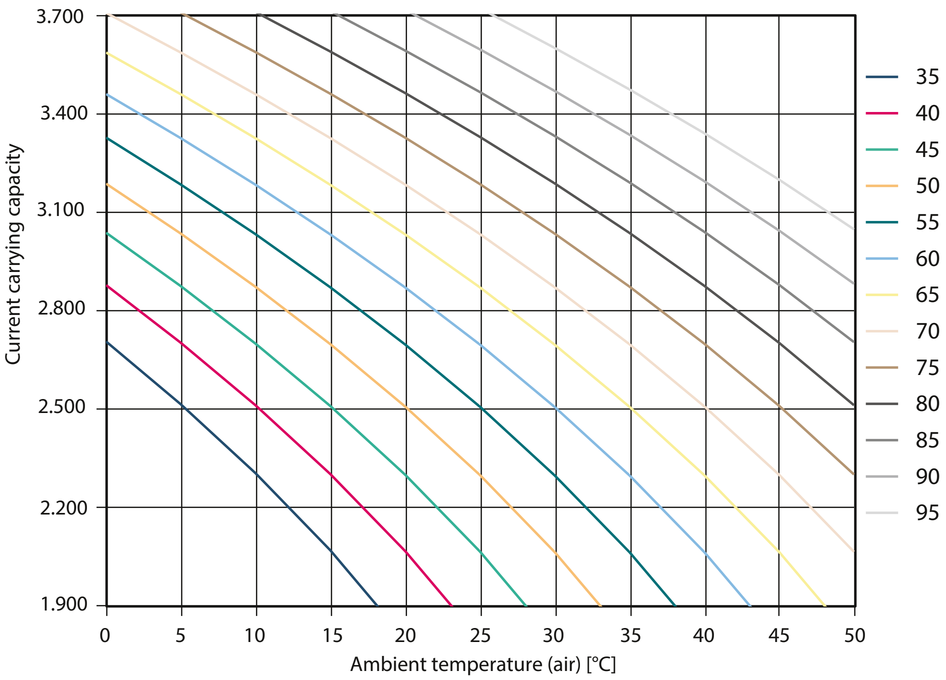


Fig. 11-3 Nominalcurrent of conductor rail ASCR 2800 (dependent on local conditions and specification)

11.04 Nominal technical data of the material

Technical data for		Aluminium	Stainless steel
specific electric conductivity, min (20 °C)	MS/m	30	–
specific electric conductivity, typical (20 °C)	MS/m	30–32	1.67
temperature coefficient of resistance	K^{-1}	0.004	0.005
yield point	MPa	170	260
tensile strength	MPa	215	450
specific weight	g/cm^3	2.7	7.7
specific heat	J/(g·K)	0.92	0.46
thermal conductivity	W/(m·K)	197	25
thermal coefficient of expansion	$10^{-6}\ K^{-1}$	23.1	10

11.05 Short circuit resistance

In the event of short circuits the rail resistant losses lead to increasing conductor rail temperature. The maximum permitted rail temperature is 200 °C, therefore, the temperature rise is mainly defined by aluminium rail heat capacity. Air cooling or heat radiation need not to be considered for such short periods. Normally, a short circuit is cleared within less than 100 ms. Therefore, short circuits do not adversely effect aluminium steel rails in view of thermal stress. It warms up very little, even during short circuits lasting extended periods of time.

Short circuit withstand of Rail ASCR 2800
Rail temperature increase from 80 °C to 200 °C

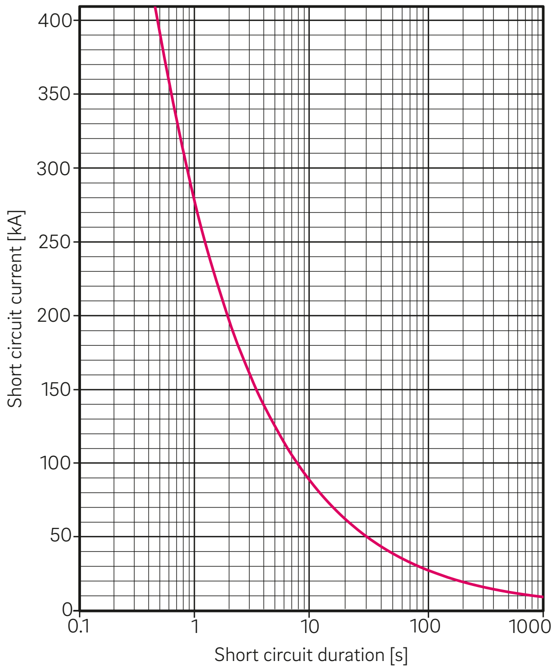


Fig. 11-4 Diagram of short circuit withstand of conductor rail ASCR 2800

11.06 Nominal current

The nominal current of the conductor rail is based on the ambient temperature and the acceptable operating temperature of the conductor rail. The table and diagram under chapter „11.03 Current carrying capacity [A]" show the values. For an ambient temperature of 20 °C and a permitted operating temperature of 80 °C, the nominal current is 3,459 A.

11.07 Mechanical properties

11.07.01 Deflection due to own weight

Deflection values of joined conductor rails due to own weight between supports are given in the diagram below:

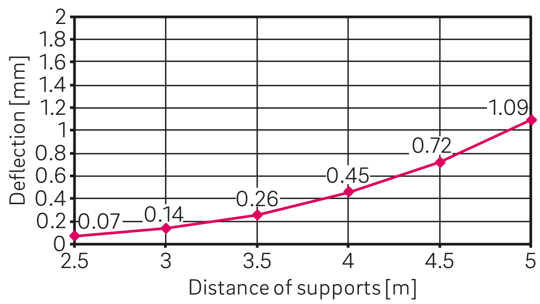


Fig. 11-5 Calculated deflection (ASCR 2800)

11.07.02 Thermal expansion of aluminium steel conductor rail

Thermal expansion of aluminium and stainless steel is different.
$\alpha_{Steel} = 10.0\times10^{-6}\ K^{-1}$, $\alpha_{Alu} = 23.1\times10^{-6}\ K^{-1}$. The overall thermal expansion of the conductor rail = $\alpha_{Alu\text{-}Steel\ Rail} = 18.8\times10^{-6}\ K^{-1}$.

12 Special Parts

Fishplates

Fish plates are being used to connect both mechanical as well as electrical the individual conductor rails and / or special parts of the conductor rail, like ramps and expansion joints.
The length of the fish plate is determined by the manufacturer of the system, should be at least 400 mm and must be pre-drilled for immediate onsite installation. Fishplates are attached with Huck bolts so that the connection cannot get loose.

Expansion joints

REHAU solutions for expansion joints are offering a large variety of possibilities to compensate the thermal expansion and secure the best electrical conductivity. REHAU variations are result of long development and testing. Expansion joints are made of conductor rail. Solutions are designed to meet customers' specific needs.

- ready for installation
- lengths 1.5 m–6 m (according to system specification)
- 1 or 2 gap system (according to system specification)
- transfer of electricity (according to system specification), i.e. cable transfer, aluminum components or copper components
- max. expansion 150 mm–200 mm (according to system specification)

Ramps

Ramps are used in the locations where gaps of the conductor rails are necessary. Height differences of ramps are adjusted according to the speed of the train and its collector shoe specifications. REHAU offers a large variety of ramp designs fitted to customers' needs.

Anchor points

Anchor points are used to fix the conductor rail, in the middle of a rail section, in order to allow thermal expansion for both directions simultaneously. Anchor points are short fishplates which are fixed to the conductor rail. Anchor points are placed at both sides of an insulator.

Cable terminals

Various versions of cable terminals are designed to meet customers' specific needs. Cable terminals are pre-drilled and therefore ready for installation. Cable terminals will be attached by using Huck-Bolts or screws.

Insulated joints

Insulated joints are made of the conductor rail.

- ready for installation
- lengths 1.5 m–5 m
- 1 or 2 gap system (according to system specification)
- e lectrically insulating

Notes

Notes

www.rehau.com/locations

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